Intel Working to Make Ultra Wideband Technology a Reality

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Overview: UWB in Transition

Ultra Wideband (UWB) is the next “big thing” in the wireless space, allowing for high data throughput with low power consumption for distances less than 10 meters. There have been a number of achievements in the industry lately with Ultra Wideband technology—from the research labs showing proof-of-concept demos to the standards group, IEEE (Institute of Electrical and Electronics Engineers) 802.15 TG3a, defining the PHY layer. But most important is that this year UWB is making a big transition—moving from the labs into standardization, and eventually into products.

At a number of Intel’s labs, researchers are taking Ultra Wideband technology out of the research phase and working to making it a standard, real-world application for future wireless products. This year some big accomplishments have come out of Intel’s labs—the first ever public demonstration of a multi-band PHY and the fastest ever data rate over UWB, topping out at an impressive 252 Mbps. In addition, Intel researchers worked with Japanese regulators and were issued the first ever UWB experimental license allowing the operation of a UWB transmitter in Japan. These accomplishments are key steps toward making UWB a reality.

What is UWB?

Ultra Wideband is a wireless technology designed for short range, personal area networks (PANs). UWB is being viewed as the next generation of wireless interconnects for PC peripherals, consumer electronics, and other mobile devices. With high available bandwidth, UWB will allow the wireless connection of multiple devices and the transmission of video, audio, and other data traffic. For example, UWB could stream video content from a PC or consumer electronics device, such as camcorder, DVD player or personal video recorder, to a flat-screen HDTV display without the use of any wires.

A UWB transmitter works by sending billions of pulses across a very wide spectrum of frequency several GHz in bandwidth. The corresponding receiver then translates the pulses into data by listening for a familiar pulse sequence sent by the transmitter. Specifically, UWB is defined as any radio technology having a spectrum that occupies a bandwidth greater than 20 percent of the center frequency, or a bandwidth of at least 500 MHz.

In the United States, the Federal Communications Commission (FCC) has mandated that UWB radio transmissions can legally operate in the range from 3.1 GHz up to 10.6 GHz, at a limited transmit power of -41dBm/MHz. Even though UWB may provide dramatic channel capacity, it can do so only at limited range due to the limited transmit power. This range has been tested and defined to be less than 10 meters (about 30 feet).

Ultra Wideband transmission uses impulses to modulate information across a very wide frequency spectrum. Impulse duration in the time domain determines the bandwidth occupied in the frequency domain. Also, UWB can take the form of either a single-band approach or multi-band approach. Each one offers advantages, but the principles of operation are the same.

Multi-Band Modulation Approach

Intel researchers have decided to pursue the multi-band approach to UWB because of its various benefits. Namely, the multi-band approach allows for good coexistence with narrowband systems (such as 802.11a), adapting to different regulatory environments, and future scalability and backward compatibility.

In this approach, the available spectrum of 7.5 GHz is split into multiple smaller frequency bands that are at least 500 MHz. This allows for implementation of a few large bands and many smaller bands, or to selectively implement bands at certain frequency ranges while leaving other parts of the spectrum unused. This dynamic ability of the radio to operate in certain areas of the spectrum is important in that it can adapt to regulatory constraints imposed by governments around the world.

Even though the FCC allows for the use of 7.5 GHz of spectrum (3.1 GHz to 10.6 GHz), other worldwide regions may have different regulatory requirements. The multi-band approach is also advantageous in that it can coexist with other wireless technologies that reside within the available spectrum. If interference is detected, a particular band can be turned off until the interference is removed. In addition, by having multiple bands, developers can design or use fewer bands for applications that don't require all the allotted bandwidth available, while other applications can implement more bands for much higher bandwidths. Implementing fewer bands reduces the cost of the radio and is thus very attractive for low-cost peripheral device manufacturers.

For more information on the UWB multi-band approach, please see Intel's IEEE UWB PHY proposal.

In order to prove the multi-band UWB approach in hardware, researchers at Intel have developed a wireless development platform to prototype the UWB multi-band technology. This wireless development platform is described in the following section.

"Ironsides" Wireless Development Platforms

Intel researchers and engineers have developed a wireless development platform code-named "Ironsides" (**Figure 1**). This platform is based on a compact PCI rack that enables developers and researchers to insert baseband and PHY boards, and "node cards," in order to create next-generation radios.

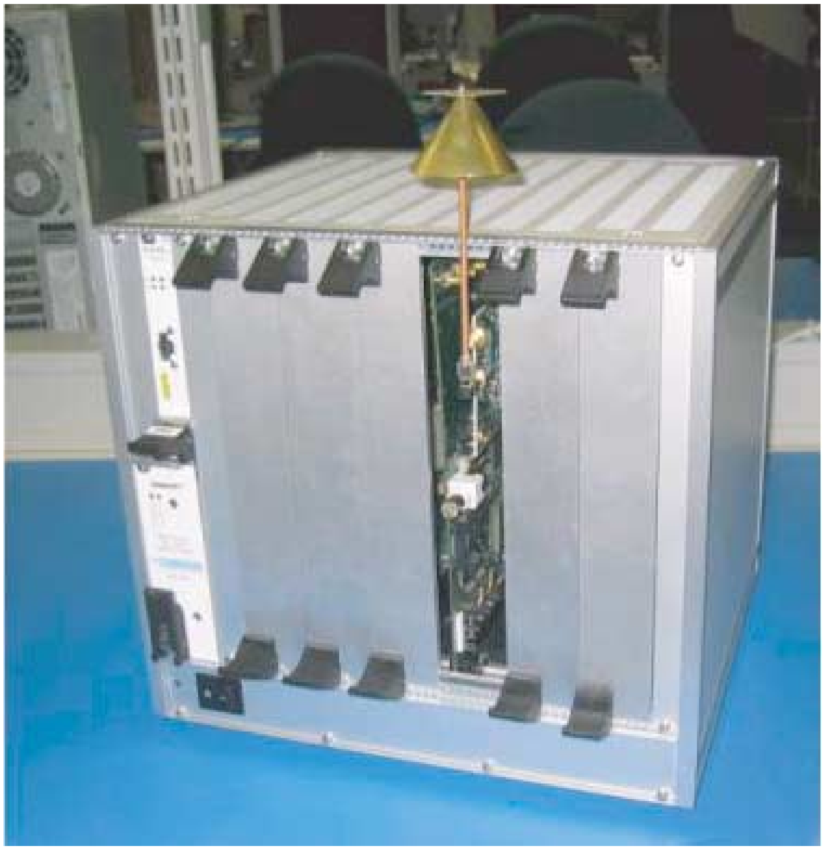

Figure 1. The "Ironsides" wireless development platform with UWB node.

The Ironsides wireless development platform is an expandable system that contains multiple node cards attached to a motherboard that provides the routing and communication control. Each one of these node cards can be any collection of unique devices that are logically grouped and provide some necessary subsystem to the radio protocol.

This platform is not only used to build and validate next-generation radios, but also to demonstrate the technology to policy and decision makers. Intel researchers used the Ironsides platform with UWB transmitter and receiver nodes to test and demonstrate the first public multi-band prototype of the UWB physical layer with data rates up to 252 Mbps.

Intel's Multi-Band Prototype of the UWB Physical Layer

Intel researchers and technologists developed a technical demonstration that showed Intel's first multi-band prototype of the UWB Physical layer. This UWB system was the very first to receive an experimental license in Japan (**Figure 2**). Intel researches worked with regulators from the MPHPT (Ministry of Public Management, Home Affairs, Posts and Telecommunications) to test the transmitter portion of the UWB demo system prior to its demonstration in Japan. The result was permission from the Japanese regulatory committee to allow the first public UWB transmission in Japan, which took place at the Intel Developer Forum (IDF) on April 11, 2003. The demo publicly showed transfer rates up to 252 Mbps.

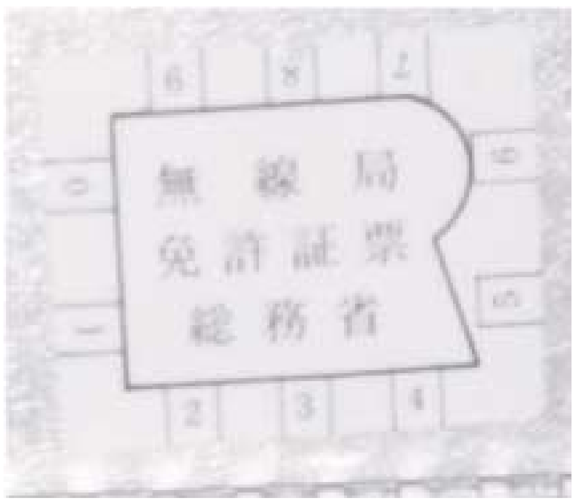

Figure 2. UWB Experimental Radio License from MPHPT in Japan

The multi-band UWB PHY layer demonstration consisted of two Ironsides research platforms, one as the transmitter and the other as the receiver, separated by approximately two meters (6 feet) distance. With one Ironsides research platform, a UWB multi-band signal was transmitted at the equivalent of 252 Mbps. This was achieved through the use of six sub-bands sending 42 Mbps of data per sub-band. The six sub-bands consisted of 500-MHz wide signals at center frequencies of 3.5 GHz, 4.0 GHz, 4.5 GHz, 5.0 GHz, 5.5 GHz, and 6.0 GHz. These sub-bands are seen in **Figure 3**.

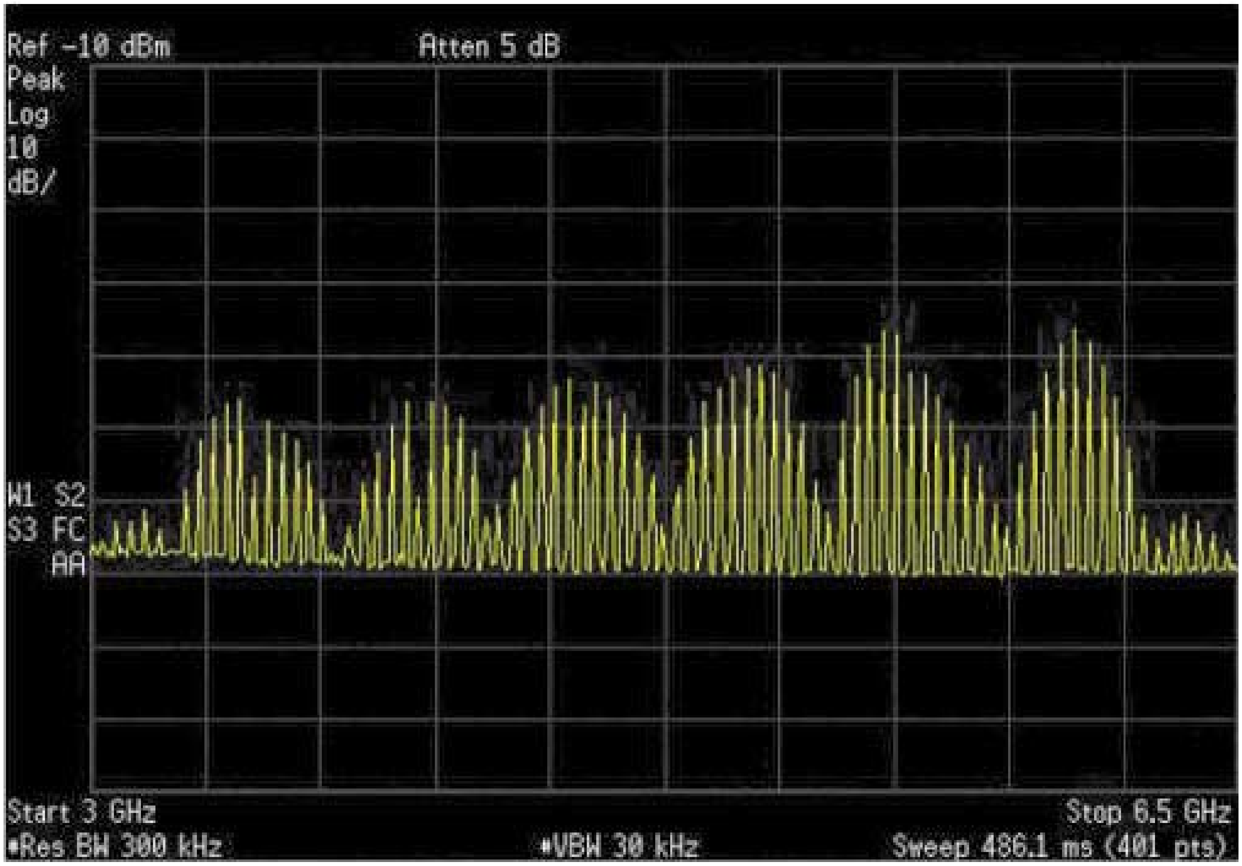

Figure 3. Six UWB sub-bands at 500MHz width, centered at 3.5 GHz, 4 GHz, 4.5 GHz, 5.5 GHz, and 6 GHz

At the receive end was another Ironsides wireless development platform with UWB receiver components receiving the six sub-bands and the data. The received data stream was processed, checked for errors, and then displayed on the screen via a PC showing the performance of each sub-band (see **Figure 4**). For each particular sub-band, the blue bar denotes the throughput in Mbps while the red bar shows the bit error rate (BER) of the received signal. The demo currently receives a data throughput rate of over 220 Mbps without errors.

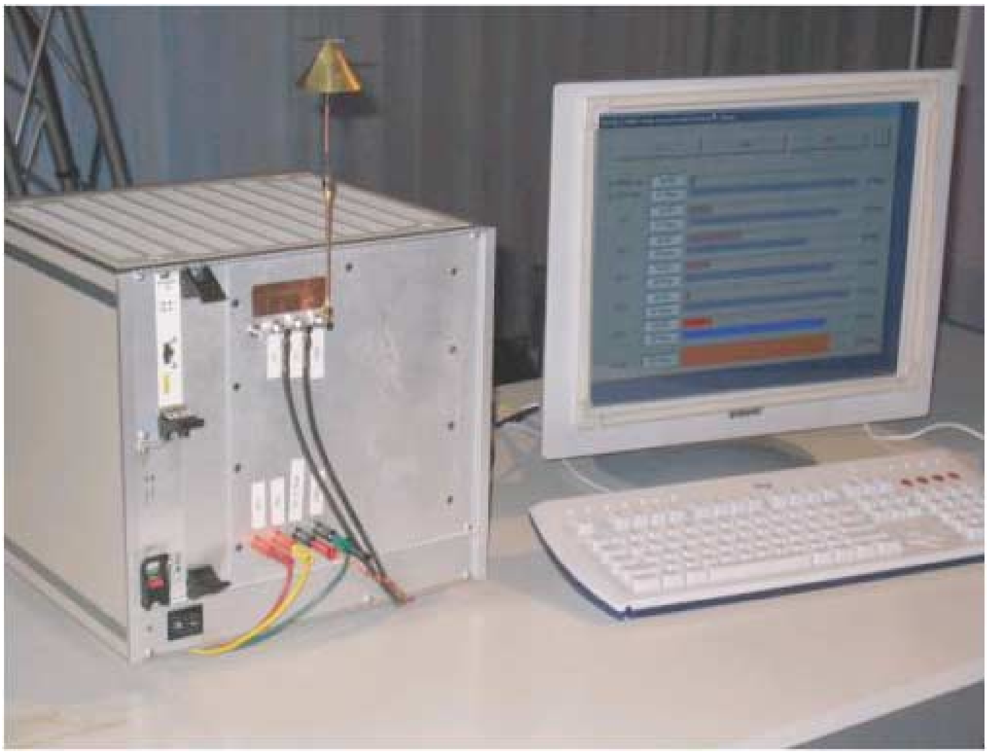

Figure 4. UWB demo receiver unit and PC displaying data throughput.

The technical demonstration also showed the ability to turn any one of the six sub-bands off, thus showing the versatility of the multi-band approach.

Intel's Multi-Band UWB PHY Proposal for IEEE 802.15.3a

In March 2003, Intel's UWB team of researchers submitted a Multi-band UWB PHY Proposal to the IEEE 802.15 High Rate Alternative PHY Task Group (TG3a). The IEEE 802.15.3 group is chartered to draft and publish a new standard for high-rate (20 Mbps or greater) WPANs (Wireless Personal Area Networks).

Intel's contribution details a proposal for a high-data-rate, short-range WPAN physical layer approach based on a multi-banded UWB system architecture. The proposal specifies characteristics of the system, which include variable data rates for different applications, flexible spectrum management techniques to adapt to different interference and regulatory environments, and scalable levels of complexity and power consumption to support devices with different implementation targets.

Since March, Intel has been working closely with other companies to refine and improve this proposal. This work includes investigation of different modulation techniques, such as orthogonal frequency division multiplexing (OFDM), for the sub-bands.

Over the course of this year, the IEEE 802.15 TG3a group will meet and hear all proposals, and then committee members will evaluate each proposal against the selection criteria. Eventually, the group will vote and a proposal will be selected to become the IEEE standard. The standardization of UWB is expected to occur within the next two years.

Summary

Through research done in Intel's labs and involvement with industry standardization through the IEEE, researchers and engineers at Intel are working to deploy UWB technology in the near future. With the standardization of a common UWB development platform, device manufacturers in the PC, mobile, and consumer electronics markets will be able to choose UWB as the physical layer, taking advantage of the low power and high bandwidth this technology provides.

Intel researchers are pursuing Ultra Wideband and believe it will be a critical step in enabling next-generation communications for a wide range consumer electronics, PC, and mobile uses in the future.

Feedback
Tell us what you think about this article.

More Info

Read the following Intel articles and white papers for more detailed explanations of the underlying technology:

- Ultra Wideband Technology Update at Spring 2003 IDF [PDF 88KB]
- Ultra Wideband Technology for Short- or Medium-Range Wireless Communications
- Ultra Wideband / a Disruptive RF Technology? [PDF 187KB]
- Intel CFP Presentation for a UWB PHY [PDF 492KB]

You can also visit these sites to explore more information:

- Intel® Ultra Wideband Site
- Ultra Wideband Working Group
- IEEE 802.15 WPAN High Rate Alternative PHY Task Group 3a (TG3a)

Author Bio

Rafael Kolic is a technical marketing manager in the Communications and Interconnect Technology Lab, part of the Corporate Technology Group. Since joining Intel in 2000, he has worked on a number of projects involving Ultra Wideband, USB 2.0, UPnP*, and several other technologies. Kolic has also performed research in the area of power electronics. He holds an M.E. in electrical and computer engineering and a B.S. in electrical engineering from the University of Florida.

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